Original Paper

Folia Phoniatrica et Logopaedica

Folia Phoniatr Logop 429
DOI: 10.1159/000XXXXXX

Medialization Thyroplasty with a Customized Silicone Implant: Clinical Experience

Viktor Chrobok[a] Arnošt Pellant[a] František Šram[b] Marek Frič[b]
Jaroslav Praisler[a] Roman Prymula[c] Jan G. Švec[b]

[a]Department of Otorhinolaryngology and Head and Neck Surgery, Regional Hospital Pardubice, and Institute of Medical Studies, University of Pardubice, Pardubice, [b]Centre for Communication Disorders, Medical Healthcom Ltd., Prague, and [c]Faculty of Military Health Sciences, University of Defence, Hradec Králové, Czech Republic

Key Words
Thyroplasty type I · Medialization thyroplasty · Paralysis · Vocal fold

Abstract
The authors implemented medialization thyroplasty with a customized silicone implant in a total of 43 operations (36 patients) in 1999–2003. In 5 of these patients, the medialization thyroplasty was combined with cricothyroid subluxation (3 cases) or adduction of arytenoid cartilage (3 cases). One patient received medialization thyroplasty, cricothyroid subluxation and adduction of arytenoid cartilage. Postoperatively 36 patients reported substantial reduction of their complaints, 5 patients found their voice improved and only 2 patients (5.6%) stated that their voice had not changed. The subjective evaluation was consistent with the findings of laryngoscopy and the preoperative and postoperative phonation parameters (maximum phonation time, maximum sound pressure level, jitter and shimmer). Average maximum phonation time was 6.5 s before surgery and 12.5 s after surgery. Maximum vocal sound pressure level was, on average, about 4 dB higher after surgery. Jitter was reduced from 5.3 to 3.7% and shimmer from 32.3 to 18.6%. The differences between presurgical and postsurgical parameters in our study were all statistically significant, indicating voice improvement. Medialization thyroplasty with a silicone implant was proven to be a successful and safe surgical method for the treatment of vocal fold paralysis.

Introduction

Vocal fold paralysis or immobility may result from neural injury or mechanical fixation of the vocal fold. Vocal fold paralysis may arise from injury to the recurrent laryngeal nerve or the vagus nerve trunk. The most common causes are previous surgery to the head, neck or chest, and neoplasms of the head, neck or thorax [1, 2]. Other causes include trauma, central nervous system diseases, inflammatory diseases or idiopathic origins. Left-sided paralysis occurs more commonly than right-sided paralysis [1]. The most common causes of bilateral vocal fold paralysis are thyroid surgery and idiopathic causes [1].

About 25–60% of patients with idiopathic unilateral vocal fold paralysis have favorable synkinesis not requir-

KARGER

Fax +41 61 306 12 34
E-Mail karger@karger.ch
www.karger.com

1021–7762/08/0000–0000$24.50/0

Accessible online at:
www.karger.com/fpl

Viktor Chrobok, MD, PhD
Department of Otorhinolaryngology and Head and Neck Surgery
Regional Hospital, Kyjevska 44
CZ–532 03 Pardubice (Czech Republic)
Tel. +420 466 015 303, Fax +420 466 650 536, E-Mail chrobok@nem.pce.cz

ing further treatment [3]. Partial reinnervation may shift the vocal fold to paramedian position, allowing for a well-compensated voice production. When vocal fold paralysis is permanent, therapy is aimed at improving closure by modifying the position of the vocal fold. Surgical intervention can be divided into four general categories: injection thyroplasty, medialization thyroplasty, arytenoid adduction and laryngeal reinnervation [4]. The aim of surgical treatments reported by most authors has been to produce sufficient glottal closure in phonation.

In the 1970s Isshiki et al. [4] designed a medialization procedure of the musculomembranous vocal fold using a synthetic implant. Several modifications of their thyroplasty type I were designed afterwards to optimize the positioning of implants and the implant material – autologous cartilage or alloplastic materials [5, 6]. Adduction arytenopexy described by Zeitels et al. [7] is a modification of the technique of Isshiki et al. [4]. Zeitels and Hillman [8] also described cricothyroid subluxation, which simulates the action of the cricothyroid muscle, varying the length and tension of the denervated vocal fold. Different techniques (leaving cartilage in place or removing it, incising the perichondrium or not) and implants (Silastic, Gore-Tex, hydroxylapatite, titanium) can be used to achieve glottal approximation [9].

In our study we examined the method of thyroplasty type I using a customized silicone block that is cut during surgery to the shape and dimensions specified by Harries and Morrison [10]. The advantage of using a silicone block over other methods is mainly its low cost. The method allows individual tailoring of the implant for every patient.

The aim of the current study was to investigate preoperative and postoperative vocal function in thyroplasty type I or thyroplasty type I with combination of posterior closure procedures (cricothyroid subluxation or arytenoid adduction) with reference to subjective and objective analysis of the voice.

Materials

Medialization thyroplasty was performed in a total of 36 patients (15 male and 21 female) in 1999–2003. In 5 of these patients thyroplasty type I was combined with cricothyroid subluxation (primary surgery in 2 cases, secondary surgery in 1 case) or arytenoid adduction with fixation of the arytenoid cartilage (secondary surgery in 3 cases); 1 patient underwent cricothyroid subluxation combined with adduction of the arytenoid cartilage. Cricothyroid subluxation or arytenoid adduction with fixation of the arytenoid cartilage was performed as a secondary intervention when poor voice quality persisted after primary thyroplasty type I.

In 29 patients unilateral paralysis of the recurrent nerve or nervus vagus was diagnosed. In 16 cases the paralysis occurred after thyroidectomy, in 6 patients after thoracic surgery, once after surgery of chemodectoma of the glomus caroticum, once after neck dissection, in 3 cases paralysis was idiopathic, probably after infection, and in 2 cases the paralysis was of obscure etiology in aortic aneurysma.

Seven patients had no vocal fold paralysis. In 3 patients the voice was impaired due to atrophy of the movable vocal fold and in 1 patient due to ankylosis of the cricoarytenoid articulation after trauma of the neck. Three patients were previously subjected to partial laryngectomy (cordectomy).

Methods of Voice Examination

A questionnaire was used for subjective evaluation of hoarseness, vocal fatigue, inadequate expectoration of mucus in the airways, dysphagia and aspiration, and dyspnea during speaking. Parameters were rated on a 3-point scale in which '0' was normal voice, '1' was moderate dysphonia, and '2' was severe dysphonia. Objective evaluation of the voice was done during the preoperative and postoperative phoniatric examination and consisted of videolaryngoscopy, videolaryngostroboscopy, as well as of the measurements of maximum phonation time (vowel /a/ or /e/), sound pressure level of the voice, jitter and shimmer.

Maximum phonation time was measured manually using a stopwatch. The patient was in a sitting position and sustained a vowel sound as long as possible on one breath. The voice analysis circuitry of the stroboscope Wolf 5052 was used for measuring the sound pressure level, jitter and shimmer of the patient's sustained phonation at comfortable loudness on the vowel /a/. The microphone was placed 30 cm in front of the mouth of the patient. The stroboscope displayed the values in the indicator on the front panel and the values were recorded manually. The measurement was done 1 day before surgery and 1 or 3 weeks after surgery.

Statistical Analysis. Comparisons between preoperative and postoperative data were done using the paired t test; p values <0.05 were considered statistically significant.

Surgical Techniques

We used the technique of medialization thyroplasty (thyroplasty type I) with a silicone prosthesis as described by Harries and Morrison [10], which was combined with posterior closure procedures in 5 cases. The size of the silicone prosthesis could be modified during surgery. Operations were performed by 2 surgeons (V.C., A.P.).

Surgical Technique of Thyroplasty Type I after Harries and Morrison [10]. The patient was in supine position with the neck extended. Local anesthesia was used in all but 4 patients who were afraid of local anesthesia and required general anesthesia. A horizontal incision 4 or 5 cm in length was made in the skin, at the midline between the lower margin of the thyroid cartilage and the thyroid notch. The connective tissue was separated laterally from the muscles to expose the thyroid ala. The window was 12 mm in men and 4 × 10 mm in women. The anterior vertical line of the window was about 5 mm distant from the median line. The upper transverse line of the window corresponded to the upper surface of the vocal fold. The cartilage was cut with a knife or with a burr if ossified. The inner perichondrium was left intact and an

Table 1. Voice parameters before and after surgery

	Patients	Preoperative measurement	Postoperative measurement	p (paired t test)
Maximum phonation time, s	25	6.50 ± 2.96	12.50 ± 2.40	0.0001
SPL, dB (uncalibrated)	13	86.00 ± 5.06	90.00 ± 7.25	0.0272
Jitter, % (normal <1.04)	13	5.38 ± 2.05	3.70 ± 1.57	0.0116
Shimmer, % (normal <3.81)	13	32.30 ± 10.67	18.63 ± 3.43	0.0085

Mean values ± SD. SPL = Sound pressure level of the voice.

elevator was used to create a pocket. The Silastic implant with shape and dimensions as specified by Harries and Morrison [10] (fig. 1) was inserted and clinched into the pocket between the inner perichondrium and the thyroid cartilage. The Silastic implant was parallel with the vocal fold. The voice was tested for the best quality during the operation under local anesthesia. Under general anesthesia, the position of the silicone implant was checked in direct laryngoscopy. The incision was closed with a drain in place. Then, the measurement of maximum phonation time and subjective quality of voice were done.

Surgical Technique of Arytenoid Adduction after Isshiki et al. [4]. General anesthesia was used in 2 cases and local anesthesia in 1 case. Skin incision was larger than that described for the Silastic implantation. The cricothyroid joint was sectioned. The cricoarytenoid joint space was opened and the arytenoid cartilage mobilized. The muscular process was identified, transfixed with a suture and rotated anteroinferiorly by leading the suture through two small holes (or a window, which is part of thyroplasty type I) created in the anteroinferior aspect of the thyroid ala.

Surgical Technique of Cricothyroid Subluxation after Zeitels and Hillman [8]. Cricothyroid subluxation was accomplished by placing a suture around the inferior cornu of thyroid lamina, when the cricothyroid joint was sectioned. The suture was passed underneath the cricoid ring anteriorly. The suture was pulled taut, increasing the tension and length of the paralyzed vocal fold.

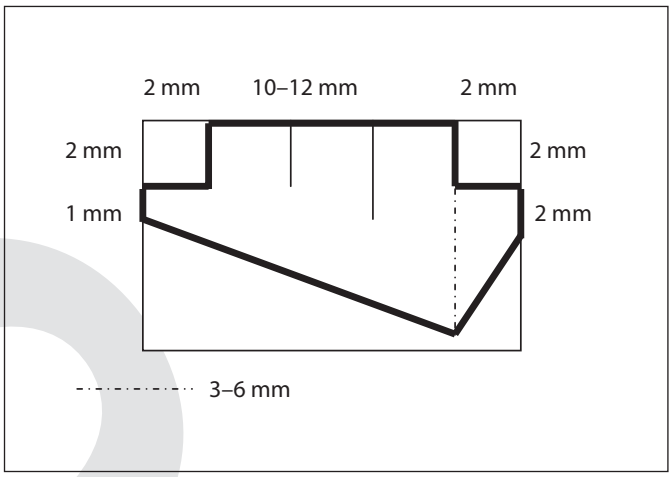

Fig. 1. Silicone implant scheme after Harries and Morrison [10]. The third distance is 5 mm for male, 4 mm for female patients.

Results

General Patient Rating

The preoperative complaints of patients were hoarseness (36 cases), vocal fatigue (25 cases), inadequate expectoration of mucus in the airways (23 cases), dysphagia and aspiration (8 cases), and dyspnea during speaking (17 cases). In all cases the voice was preoperatively evaluated as being severely dysphonic (parameter '2').

Postoperatively, in 29 patients (80.6%) substantial reduction of complaints was reported (parameter '0', normal voice), 5 patients (13.8%) reported on improvement of their voice (parameter '1', moderate dysphonia) and 2 patients (5.6%) found their voice had not changed (parameter '2', severe dysphonia). These 2 patients had undergone cordectomy.

Videolaryngoscopy and Videostroboscopy

Laryngeal videostroboscopic examination revealed improved glottal closure during phonation in all patients after surgery. In 5 of them medialization thyroplasty was combined during the second surgery with cricothyroid subluxation (3 cases) or with arytenoid adduction and fixation of the arytenoid cartilage (3 cases) for incomplete closure of the posterior (cartilaginous) third of the glottis. The mucosal wave was absent in 3 patients after cordectomy and thyroplasty type I because the vocal fold was very stiff.

Maximum Phonation Time

The change in maximum phonation time before and after surgery is shown in table 1. The average maximum

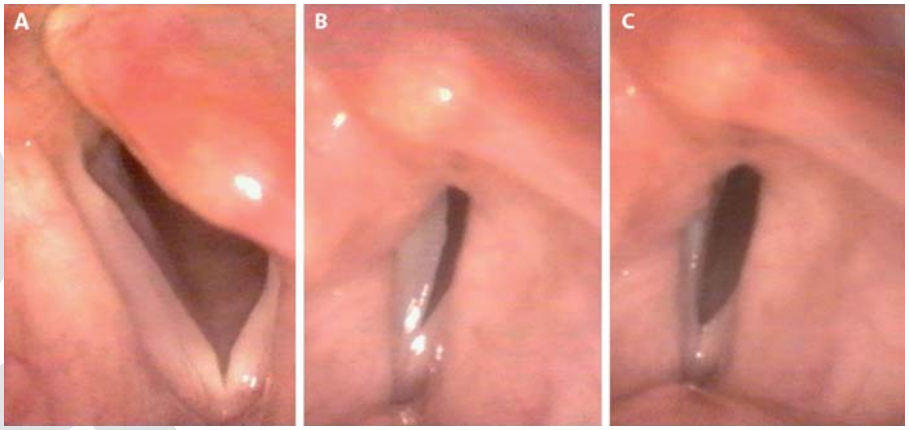

Fig. 2. Laryngoscopic findings before surgery. Patient: female, age 70. **A** Laryngoscopy during breathing. The apex of the left arytenoid cartilage is tilted ventromedially, crossing the midline. **B** Maximum glottal closure during phonation in stroboscopy. There is a glottal gap along the whole vocal fold length indicating inefficient phonation. **C** Maximum glottal opening during phonation in stroboscopy.

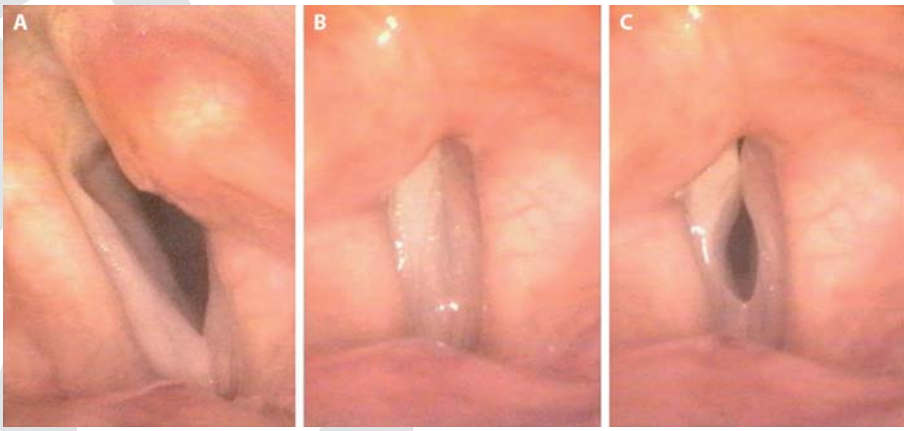

Fig. 3. Laryngoscopic findings after surgery (same patient as in fig. 2). **A** Laryngoscopy during breathing. The glottal gap is slightly smaller due to the surgical medialization of the paralyzed vocal fold. **B** Maximum glottal closure during phonation in stroboscopy. No glottal gap is visible. **C** Maximum glottal opening during phonation in stroboscopy.

phonation time was 6.5 s before surgery and 12.5 s after surgery. The paired t test (0.0001) was statistically significant.

Maximum Sound Pressure Level

The maximum sound pressure level of the voice was, on average, about 4 dB higher after surgery (table 1). The paired t test (0.0272) was statistically significant.

Jitter and Shimmer

Twelve out of 13 patients showed reduced jitter after surgery and 10 out of 13 patients showed reduced shimmer after surgery (table 1). The paired t tests (0.0116 and 0.0085, respectively) were statistically significant.

Examples of the laryngoscopic findings and voice range profiles before and after surgery are demonstrated in figures 2–4.

Complications of Surgery

In 1 patient a postoperative complication was observed when the prosthesis dislocated from the window in the thyroid cartilage. The postoperative dislocation of prosthesis was managed by view of videolaryngoscopy; there was no medialization of the vocal fold, quality of voice was not better and surgical revision was necessary. One patient complained of a postoperative scar on the neck. No patient had inspiratory dyspnea after surgery.

The average duration of the thyroplasty procedure under local anesthesia was 47 min (minimum 35 min, maximum 75 min). The duration of hospitalization was between 5 and 7 days.

Discussion and Conclusion

In our study, 34 (94.4%) of the total of 36 patients reported improvement of their condition. Only 2 patients (5.6%) reported that their condition had not changed; these patients had undergone cordectomy and the poor outcome can be explained by scarring of the vocal fold. Our results are comparable to the study of Schneider et al. [11], who reported subjective improvement of the voice

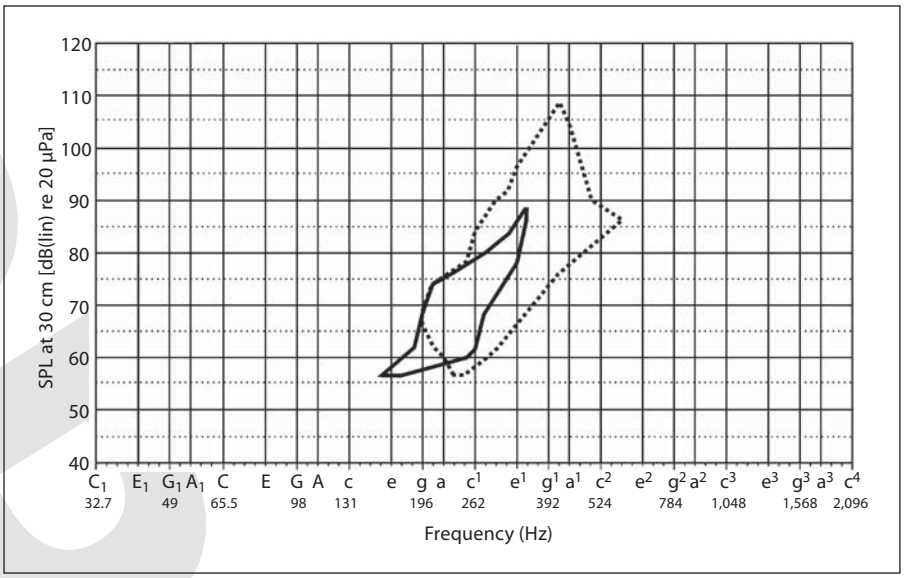

Fig. 4. Voice range profiles before (10.2.1998) and after surgery (14.4.1998) corresponding to the laryngoscopic images in figures 2 and 3, respectively. After surgery, the dynamic range is increased by 20 dB towards louder phonation and the pitch range is expanded towards higher frequencies in this case.

in all 28 patients. In 8 of these patients, medialization of the vocal fold improved not only the voice but also the dysphagia and aspiration associated with vocal fold paralysis.

The average maximum phonation time was longer after surgery (12.5 s) than before surgery (6.5 s). These findings are consistent with those of Lundy et al. [12], who used thyroplasty type I in the classic manner, and confirm that maximum phonation time is a good functional and objective measure of glottal competence, suitable for predicting the postoperative outcome of medialization thyroplasty. Lundy et al. [12] recommended intraoperative measurement of maximum phonation time, which was an adequate predictor of postoperative outcome, but the maximum phonation time was significantly lower in the supine versus the seated position. We therefore compared maximum phonation time in the same (i.e., seated) patient position.

Sound pressure level increased on average by 4 dB after surgery in our study. Most patients had lower jitter and shimmer after surgery. Jitter was reduced from 5.3 to 3.7% and shimmer from 32.3 to 18.6%. The differences were all statistically significant, indicating voice improvement. On average, jitter and shimmer did not reach normal values. In our study, the jitter values are slightly higher than those reported by Giovanni et al. [13], who found preoperative jitter of 14.5% and postoperative jitter of 0.88%.

Most authors prefer the medialization thyroplasty procedure over the injection techniques [5, 6, 14] because the laryngeal framework surgery does not alter the lamina propria and the thyroarytenoid muscle [1], but there are also numerous reports on excellent results using injection laryngoplasty [3, 6]. As both these techniques have their specific roles they should be considered as being complementary rather than competitive. Precise positioning of the thyroid lamina window is very important in medialization thyroplasty. Precise positions of the window and prosthesis are determined by careful and correct measurement of critical point and window corners during surgery. We made the window with the knife or drill. An ultrasonic surgical aspirator may be an effective, efficient alternative to the standard drill for making the thyrotomy window [15], but it was not used here.

Besides the silicone block, also other implant materials have been used for medialization thyroplasty. In the past, cartilage material was used [4], but such an implant has a disadvantage as there is the possibility of its resorption. Friedrich et al. [9] demonstrated a successful external vocal fold medialization with an adjustable, preformed titanium vocal fold medialization implant [11]. For economic reasons, we used the silicone prosthesis by Harries and Morrison [10]; the prostheses were prepared individually during surgery.

Although thyroplasty type I is an excellent medialization technique, it may need to be combined with a posterior closure procedure in patients with large posterior gaps [2]. In our study, this was required in 6 patients with large posterior gaps and was done using cricothyroid sub-

luxation combined with the adduction of the arytenoid cartilage.

The percentage of airway complications after medialization thyroplasty is low. However, the surgical adduction and fixation of the arytenoid cartilage has a significant risk of postoperative temporary tracheostomy [16]. In our study only 2 patients (5.6%) had complications after surgery and 2 other patients (5.6%) had no change of voice after surgery. We therefore conclude that medialization thyroplasty with a silicone block is a successful and safe surgical method with stable phonatory results for the treatment of vocal fold paralysis.

Acknowledgments

The research has been supported by the Project EUREKA Σ! 2614 NEWVOICE.

References

1 Courey MS: Diagnosis and surgical management of unilateral and bilateral vocal fold paralysis. Curr Opin Otolaryngol Head Neck Surg 1995;3:120–124.
2 Omori K, Slavit DH, Kacker A, Blaugrund SM, Kojima H: Effects of thyroplasty type I on vocal fold vibration. Laryngoscope 2000; 110:1086–1091.
3 Sinacori JT: Unilateral and bilateral vocal fold paralysis: techniques and controversies in management. Curr Opin Otolaryngol Head Neck Surg 2002;10:472–477.
4 Isshiki N, Morita H, Okamura H: Thyroplasty as a new phonosurgical technique. Acta Otolaryngol 1974;78:451–457.
5 Tsunoda K, Takanosawa M, Niimi S: Autologous transplantation of fascia into the vocal fold: a new phonosurgical technique for glottal incompetence. Laryngoscope 1999;109: 504–508.
6 Zeitels SM, Healy GB: Laryngology and phonosurgery. N Engl J Med 2003;349:882–892.
7 Zeitels SM, Hochman I, Hillman RE: Adduction arytenopexy: a new procedure for paralytic dysphonia and the implications for medialization laryngoplasty. Ann Otol Rhinol Laryngol 1998;107(suppl 173):1–24.
8 Zeitels SM, Hillman RE: Cricothyroid subluxation for enhancing laryngoplastic phonosurgery. Ann Otol Rhinol Laryngol 1999; 108:1126–1131.
9 Friedrich G, de Jong FI, Mahieu HF, Benninger MS, Isshiki N: Laryngeal framework surgery: a proposal for classification and nomenclature by the Phonosurgery Committee of the European Laryngological Society. Eur Arch Otorhinolaryngol 2001;258:389–396.
10 Harries ML, Morrison M: Short-term results of laryngeal framework surgery – thyroplasty type 1: a pilot study. J Otolaryngol 1995; 24:281–287.
11 Schneider B, Denk DM, Bigenzahn W: Functional results after external vocal fold medialization thyroplasty with the titanium vocal fold medialization implant. Laryngoscope 2003;113:628–634.
12 Lundy DS, Casiano RR, Xue JW: Can maximum phonation time predict voice outcome after thyroplasty type I? Laryngoscope 2004; 114:1447–1454.
13 Giovanni A, Vallicioni JM, Gras R, Zanaret M: Clinical experience with Gore-Tex for vocal fold medialization. Laryngoscope 1999; 109:284–288.
14 Rihkanen H, Reijonen P, Lehikoinen S, Lauri ER: Videostroboscopic assessment of unilateral vocal fold paralysis after augmentation with autologous fascia. Eur Arch Otorhinolaryngol 2004;261:177–183.
15 Halum S, Patel N, Hoffman RG, Simpson CB, Merati AL: Medialization thyroplasty window creation using an ultrasonic surgical aspirator. Laryngoscope 2005;115:155–158.
16 Weinman EC, Maragos NE: Airway compromise in thyroplasty surgery. Laryngoscope 2000;110:1082–1085.